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# The role of anaesthesiology and intensive care for patient safety in the perioperative period: past, present and future

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On February 6, 1847, the surgeon Professor Ludwik Bierkowski (whose bust is pictured below on the square at 7 Kopernik St. in Krakow) used ether to anaesthetise a patient for the first time in Poland. This took place in Krakow — 170 years ago — less than 5 months after the first use of ether for general anaesthesia by William Morton in Boston on October 16, 1846.

Until that time, surgical procedures were characterised by unimaginable pain and stress, as a result of which the mortality rate of operated patients immediately after or during surgery was probably very high, reaching double-digit percentage values. The practical introduction of ether, as well as chloroform (by Scottish physician James Young Simpson in 1847) and nitrous oxide (by Horace Wells in 1845) expanded operational capabilities in the second half of the nineteenth century. Although little is known about the safety of patients being treated at that time, anaesthesia-related mortality reported for the first time by Ernst Gurtl on a group of several hundred thousand patients [1] during the period 1890–1895 was as follows: for chloroform anaesthesia — 1 death per approximately 2,000 surgeries; ether — 1 death per approximately 6,000 surgeries; and for combined anaesthesia with an ether-chloroform mixture — 1 death per approximately 10,000 surgeries. The latter rate


**Figure 1.** Laying flowers at the bust of Ludwik Bierkowski on the occasion of the 170th anniversary of the first operation with ether anaesthesia in Poland (left to right: Prof. Janusz Andres, Prof. Jerzy Wordliczek, Prof. Piotr Knapik, Prof. Zdzisław Gajda)

is worth emphasising, especially in the light of data on anaesthesia-related mortality during the period 1970–1980, in which there were around 2 deaths per 10,000 anaesthetic procedures [2]. It should be assumed that anaesthesia with ether, even in combination with chloroform, was then a relatively safe method of general anaesthesia for people with a low operational risk in today's sense. In addition, at the end of the 19th century, the medical world began to pay attention to difficult-to-explain cases of sudden death both during surgery and in the immediate postoperative period. The cases of intraoperative deaths were most often associated with the toxic effects of chloroform on the cardiovascular system, postoperative fatal complications, in addition to infections, as well as upper airway obstruction due to the prolonged effect of anaesthesia and a lack of postoperative surveillance. Starting from 1880, as a result of the frequent occurrence of intraoperative cardiac arrest during anaesthesia with chloroform, the techniques of resuscitation such as open (1880, Paul Niehans) and closed (1883, Franz Koenig) chest cardiac massage were described [3]. The technique of compressing the closed chest (often with simultaneous epigastric pressure) along with manual ventilation in cases of "collapse" caused by chloroform became known in Central Europe in the decades which followed and was used in anaesthetised patients whose pulse was ceasing to be perceptible. Since 1900, intra-tracheal intubation (Franz Kuhn) was also applied and developed from the 1930s on by the founder of the first Chair of Anaesthesiology in Europe, Sir Robert R. Macintosh. It was he who drew professional attention to the relationship between the general condition of the operated patient and the possible side effects of the applied anaesthetics and methods of anaesthesia for the first time. He is the author of a well-known definition of anaesthesia, namely: *deadly easy-easily death*, which can be explained as terming anaesthesia a deadly straightforward method which can easily lead to death. His well-known publication from 1949 [4] is not outdated, even today, due to its universal references to patient safety, such as: avoiding untimely death — in the sense of *avoiding unnecessary death*; keeping a registry of deaths related to anaesthesia; the mandatory inspection of equipment (*checking is imperative*) before anaesthesia, regardless of the place where the anaesthesia is performed; promoting the need to supervise the patient after surgery; as well as the continuous education of medical personnel. In the mid-twentieth century, it also became clear that one should distinguish between death due to anaesthetic causes and death indirectly related to anaesthesia, independent of anaesthetic factors. Sir Robert Macintosh is also the author of the concept: *There should not be death due to anaesthesia*. An important factor influencing the development of the concept of safety was the introduction in 1928 of a written report, the so-called anaesthesia chart, on the basis of which it was possible to analyse cases of complications retrospectively. Deaths during anaesthesia caused by human error such as, among others, the mistaken administration of nitrous oxide instead of oxygen at the end of anaesthesia became the cause of well-known media campaigns and press reports in the 1980s [5] and significantly contributed to the interest of anaesthetists in introducing safety standards, as well as in education and research in this area. Today, in the second decade of the 21st century, anaesthesia is safe, which manifests itself in 0.05 deaths for strictly anaesthetic causes per 10,000 anaesthetised patients [6] and is comparable to the safety of civil aviation passengers, considered the standard in safety. There are many indications, however, that such a comparison is not entirely valid as the anatomical and physiological functions of the human body are much more complex than the most complex technical device. The progress that has been made in anaesthesiology and intensive care since the time of Bierkowski is extraordinary and has been associated with the constant improvement of safety and operational capabilities based on new drugs (1942, muscle relaxants; 1951, modern inhaled anaesthetics) and, above all, oxygenation (pulse oximetry) and breathing (capnography) monitoring techniques (from 1980) used on the operated patient. The Polish Society of Anaesthesiology and Intensive Care, founded in 1959, has always been among those societies whose active international and domestic activity, regardless of political and economic circumstances, allowed for the implementation in Poland of all technological and educational innovations in anaesthesiology and intensive care, which resulted in the standards of education and clinical practice in this discipline in Poland corresponding to and meeting the highest European standards. This does not mean, however, that we have achieved the optimum in terms of safety, and there are many indications that we will probably never be able to completely free ourselves from medical errors. Seventeen years have passed since the publication of *To err is human* [7], in which it was recalled that human beings and the medical world are prone to errors (*errare humanun est*) due to the fact that the complicated organisation and multifactorial character of diagnostic and therapeutic processes are particularly vulnerable to errors. The proposals to eliminate some of them, or at least to reduce the incidence of medical errors, are associated with the education of medical personnel in the field of "safety culture." Practical error elimination systems consist mainly of introducing inspection and barrier systems in medical procedures aimed at protection against medical errors, which is graphically depicted by a model of a series of Swiss cheese slices with holes arranged one behind the other constituting additional barriers in the event that the first,

second or third barrier fails. Nevertheless, estimates from the USA concerning 2013 indicate that medical error is still the third-highest cause of death in hospitals after causes such as cancer and heart disease [8]. In 2010, on the initiative of the European Society of Anaesthesiology (ESA), the Helsinki Declaration on Patient Safety in Anaesthesiology [9] was published and accepted by all Societies of Anaesthesiology and Intensive Care in European countries, which underlined the key role of anaesthesiology in ensuring patient safety in the perioperative period. The main justification for this declaration was the fact that, annually on a global scale, 7 million patients undergoing surgery develop severe complications, 1 million die of complications, while 200,000 deaths per year occur in Europe alone. On the one hand, the Helsinki Declaration makes us aware of the great problem of peri-operative complications on a global and European scale, and on the other, proposes remedies and organisational measures to avoid these complications. The basic requirements mentioned in the Helsinki Declaration boil down to the necessity of meeting the criteria for monitoring the patient's vital signs, the introduction of safety procedures and continuous monitoring, as well as annual reporting of morbidity, mortality and the occurrence of critical events, especially in the perioperative period, in order to prevent such events. In this respect, the declaration is of great educational and promotional importance, providing a practical solution to the problem of local factors. One of the basic requirements of the Helsinki Declaration is to support the initiative of the World Health Organization by introducing a perioperative inspection chart entitled "Safe Surgery Saves Lives." Its use has significantly reduced (almost by half) both morbidity and perioperative mortality, proving that simple organisational measures can significantly affect the long-term effects of treatment (provided that these effects are monitored). Another proposed way to improve the safety and efficiency of treatment of patients in critical situations may be the introduction of workflow schemes in critical situations (so-called *checklists*) on the model of commonly available CPR algorithms of the European Resuscitation Council, but concerning the crisis situation of a patient being treated in a hospital. One example is an article on the website of the Polish Resuscitation Council that presents emergency procedures aiming to prevent and manage sudden unexpected cardiac arrest during anaesthesia [10]. In 2013, the ESA published a list of prevention and management checks in the most frequently occurring critical situations during anaesthesia, the so-called *ESA Safety Kit* available at www.esahq.org [11]. These materials can be translated, modified and adapted to local needs. Also in 2013, an editorial published in the *European Journal of Anaesthesiology* called for efforts to develop guidelines for the management of sudden unexpected cardiac arrest [12]. This ESA initiative has its counterpart in the *Anaesthetic Crisis Manual — ACM —* by David Borshoff, available at www.theacm.com.au and widely distributed in Australia and the USA. An anaesthesiologist's manual in Polish entitled "Critical Situations During Anaesthesia" is available through the www.prc.krakow.pl website. This manual is designed to be used as a cognitive aid based on checklists. However, it cannot replace clinical experience, good education, regular practice, as well as training in a simulation centre. Five years ago, William Berry stated the following in the editorial commentary of the *Canadian Journal of Anesthesia* [13], namely: "No patient whose death is avoidable should die in the operating room or hospital — ever" Despite this extremely ambitious statement, a data analysis based on large observational groups, namely recent multi-million cases of patients operated on in Europe and the USA, indicates a worryingly high number of postoperative complications, including death. In the 2012 Pearse study, carried out on a group of approximately 50,000 patients operated on in Europe, an average of 4 patients out of 100 died in the immediate postoperative period with large variations in individual countries [14]. Published results from the American Society of Surgeons register, based on a database of 1.3 million surgeries, showed that 1 out of 200 operated patients underwent cardiopulmonary resuscitation in the immediate postoperative period, 70% of whom died within 30 days of surgery [15]. In contrast, the national register of the results of anaesthesia [16] from the USA, covering almost 11.5 million surgeries, revealed 3 deaths per 10,000 cases during anaesthesia and the recovery period in the anaesthetic ward, which is rather surprising and reminds one of the data from the 1980s. The contemporary development of medicine, and especially its development in the last 30 years, is incomparable to earlier periods in terms of the range of performed operations and the general condition of patients. Similarly, although it is difficult to anticipate the further development of anaesthesiology and intensive care, this does not mean that visions of such developments do not exist, as I will discuss later in this article. Surprising observations made in the above-quoted publications [14–16], as well as current data on the occurrence of perioperative cardiac arrest in non-cardiac surgery (about 1 case of cardiac arrest per 10,000 anaesthetic procedures in adults and 3–4 times more in children [17]) indicate the need to modify the standard of practice in the perioperative period, both in terms of eligibility for surgery, adequate monitoring and the prevention of complications, as well as to elaborate clinically useful recommendations along with guidelines in the field of ethics. The elaboration of any subsequent recommendations for practice should, however, take into account the realities of health systems and be based on the need to

adapt to local conditions while respecting the doctor-patient relationship and maintaining patient's autonomy [18].

In the last decade, although the number of registered anaesthesiologists in Poland has significantly increased, the growing needs of the health care system in our country have caused a constant increase in the demand for specialists in this field and their permanent shortage — a trend that is characteristic for all countries in Europe. Forecasts for the development of medical services predict an increase in the demand for so-called perioperative medicine specialists, in which anaesthesiologists increasingly play an important role in enabling the use of modern operating methods and intensive care, as well as the introduction of recognised safety standards. What can we expect in the decades to come? What will anaesthesiology and intensive care look like in, say, 2050? Although it is unlikely that those who are writing these words and the authors of the quoted opinions will still belong to the land of the living at the time, and taking into account Niels Bohr's statement that "prediction is very difficult, especially when it comes to the future", I hereby present selected views on the possible development of anaesthesiology and intensive care based on currently published analyses and visions, which, in my opinion, are not entirely devoid of the possibility of implementation.

— An anaesthesiologist, as a key doctor of perioperative medicine based on interdisciplinary cooperation with doctors of other specialties, will deal with particularly burdened and sensitive patients with increased perioperative risk, bearing in mind, above all, the optimal long-term treatment outcome. Probably, an anaesthesiologist will anaesthetise and treat not only increasingly older (90–100-year-old) patients, but he will have to be ready to continue working as long as conditions permit, being aged 70 and over [19].
— Bearing in mind the dynamic development of robotics, one can imagine that many anaesthetic procedures will be automated and robots will be able to perform both the doctor's and the nurse's work in many areas of anaesthesiology and intensive care. I hope, of course, that clinical decisions will continue to be made by medical personnel based on full diagnostic data and ongoing monitoring of all the physiological parameters of the patient. In terms of monitoring, we may expect rapid and great progress, perhaps in the next 10–20 years. Non-invasive, wireless and always-on smart "monitoring clothes" with built-in systems of analysis and early warning of adverse trends in the general condition of the patient, provided with algorithms to prevent complications and to treat them, will be available to all patients. Non-invasive, ergonomic, wireless and wearable vest systems for continuous monitoring of the central nervous system together with saturation, blood pressure, temperature and depth of anaesthesia will integrate the ECG record with the respiratory rate, measurement of chest volume, cardiac output and diagnostic imaging capabilities, an electronic tattoo will monitor the heart rate, respiration, temperature, electrolyte level and blood lactate, while a glove will measure the radial artery pressure, pulse, cardiac output, blood saturation, haemoglobin level, and thumb muscle saturation [20].
— Many changes may be expected in the decades to come regarding the function and appearance of intensive care units. Hospitals are likely to have an increased number of intensive care beds, and according to many forecasts, they will almost entirely be devoted to intensive care for cases with a positive outcome prognosis, while all other medical activities will probably be conducted on an outpatient basis — as we understand this today. Treatment (the treatment of pain, sepsis, organ failure, antibiotic therapy, etc.) will be individualised for each patient according to his or her genetic type, based on continuous and integrated analysis of all individual patient data. Such a vision of intensive care of the future is based on the concept of a calculated genetic analysis of the patient, which will allow the clinician to recognise any pathological changes within the structure and function of inefficient organs and to design appropriate treatment to restore their function or their reconstruction [21].

I am aware that these visions may remain *science fiction*, and possible progress in the field of anaesthesia and intensive care will be carried out in completely different ways, as it was the case in the recent past, when nobody predicted the extremely dynamic development of the Internet and the subsequent demand for personal computers.

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